URUGUAYAN NATIONWIDE BEACH REMOTE MONITORING INITIATIVE

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INTRODUCTION

Uruguayan coast is mainly constituted by sandy beaches, with an extension of approximately 700 km: 300 km corresponding to the Río de la Plata (RDP) estuary, and 400 km facing the south Atlantic Ocean. Sandy beaches are dynamic environments that change at different spatial and temporal scales, such as storm, seasonal and inter annual scales. The understanding of these dynamics is fundamental for the management of the coastal zone, where decision makers are constantly challenged when facing beach erosion and coastal flooding. As these problems become more pressing due to the rise in mean sea level caused by climate change, information on beach dynamics is essential for proposing successful adaptation strategies. Furthermore, since adaptation strategies will need to be reviewed periodically, it is essential to have operational beach monitoring systems.

In this context, over the last years remotes sensing has become a widely extended trend for beach monitoring, enabling to generate information with greater coverage and resolution both temporally and spatially in comparison with in situ measurements. In that sense, Uruguay has implemented a nationwide beach remote monitoring system based in images from three different sources: satellite, video cameras and cellphones within the citizen science project CoastSnap.

Here we describe the implementation of the system, the information generated so far, and the use that has been made of it for beach management and the proposal of climate change adaption measures.

METHODOLOGY

The national beach monitoring initiative is carried out through an agreement between the Ministry of the Environment and the Engineering School of Universidad de la República, with the active participation of the local governments involved in beach management.

The first source of information includes satellite imagery from Landsat and Sentinel missions, publicly available in Google Earth Engine, and cover the period 1985 – present along all the coastal extent, with a sample frequency varying from one image per month in the first 15 years to an image per week currently; and a spatial resolution from 15 m to 10 m. For each image, a shoreline detection algorithm is implemented using the open toolkit CoastSat (Vos et al. 2019), defining the shoreline as the instantaneous interface between water and sand. The algorithm implements image segmentation with Otsu's thresholding method at subpixel resolution. With this method, a shoreline database is generated and then post – processed by analyzing beach evolution and long-term trends in cross shore transects defined all along the coast every 100 m.

The second component of the system are images obtained from video cameras situated in building rooftops with large visibility along the beach, currently in four sites along the Uruguayan coast, and two more to be installed during 2024. Ten minutes videos are recorded hourly and then processed to obtain shoreline position (Figure 2). Timestack images are also being extracted to obtain other variables. Video cameras are calibrated with in situ measurements in order to undistort and ortho rectify each image before the shoreline detection.

Finally, crowd-source images from smartphone cameras are used for shoreline mapping as a part of the national implementation of the citizen science project CoastSnap (Harley and Kinsela 2022). To the date, six stations have been installed, each one consists of a short pole with a frame to place the phone, and a sign with instructions to share the picture. These images are processed similary to the ones obtained from video cameras, being ortho rectified before mapping the shoreline.

The information obtained from the three sources has been processed for different applications, and its generation has been systematized and automatized. Various technology transfer workshops have been organized so that national and local government technicians involved in beach management have access to the generated data base. For this purpose, some easy-to-use tools have been developed (e.g. Jupyter Notebooks) that allow them to obtain quick answers to the most common questions they face in their daily tasks (e.g. is a stretch of coastline undergoing erosion or accretion; what is the seasonal or interannual variability of a stretch of coastline, etc.).

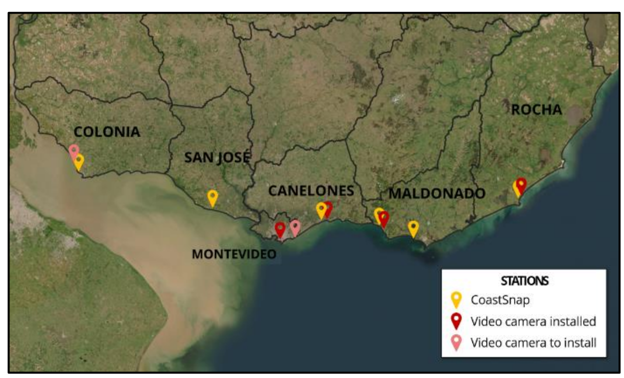

Figure 1 – M onitoring stations and Uruguay administrative districts.

Figure 2 - Example of a camera frame (a), and ortho-rectification and shoreline detection (b).

RESULTS

The three sources have proven to provide useful information, giving precise results of the shoreline position. Figure 3 shows a comparison of the shorelines obtained with the three different techniques with in-situ GPS measurements for the case of Atlántida.

In the case of satellite imagery, the wide temporal coverage has enabled to determine the evolution of specific parameters such as beach width and area at a national scale. As an example, Figure 4 shows the time series of changes in the total beach area per administrative district, from 2001 to 2021, in comparison with the area available in 2000. It is noted that the greatest variability occurs in Rocha, the district with most intense wave action (Alonso and Solari 2021), and that for the rest of the districts there is an accretion trend.

These examples exhibit the system capacity to provide useful information, that is already being used for coastal management, land use planning, and the proposal of climate change adaptation measures. However, the most relevant aspect is that the beach monitoring system integrates to the existing national monitoring systems of oceanic variables: sea level measured at seven coastal stations along the approximately 700 km of the Rio de la Plata and Atlantic Ocean coasts, and two wave buoys (one in the Atlantic Ocean and the other in the mid Rio de la Plata). In addition, it is planned that the system will complement these stations by incorporating another wave buoy in the inner Rio de la Plata.

Taken as a whole, the system is innovative, aimed at providing a robust tool for the adaptation of Uruguayan beaches to climate change, as well as for the monitoring of adaptation measures to be implemented in the coming years.

REFERENCES

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Figure 3 - Comparison of video, CoastSnap and Satellite derived shorelines, with in situ measured shoreline (GPS), for Atlántida, Canelones.

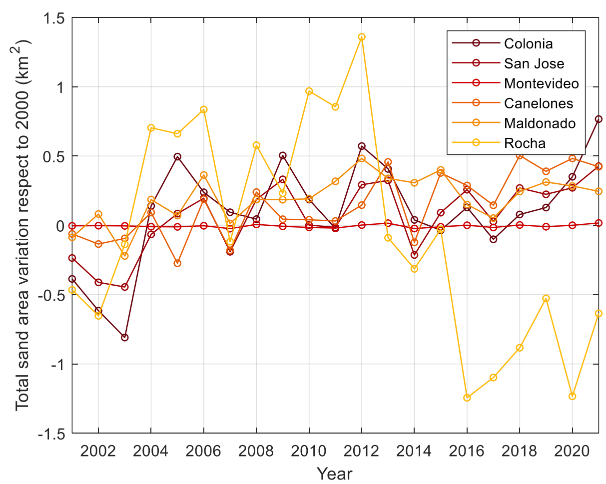

Figure 4 - Annual beach area variation respect to 2000's median shoreline per department.

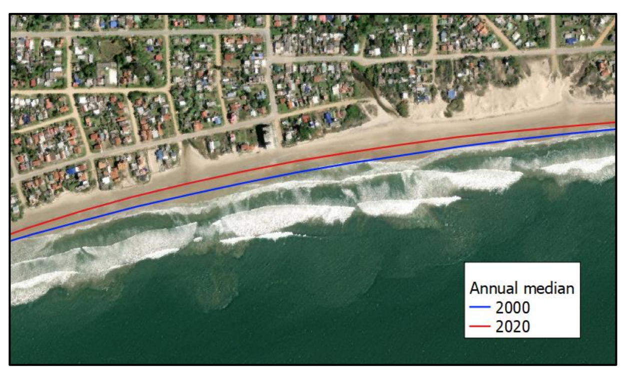

Figure 5 - Example of annual median shoreline in Rocha.